Claims

1.   Reciprocating engine used between a minimum speed of rotation Nmin and a maximum speed Nmax, which comprises a turbocharging unit (2) dimensioned so as to function autonomously when:

➢   it supplies the intake manifold (8) of the engine with air via a cooler

➢   it is supplied with gas by the exhaust manifold (9, CR and CT) of the engine at the exhaust temperature

➢   the turbine supply pressure (P3) is substantially equal to the compressor discharge pressure (P2),

in such a way that at constant air temperature and with a fixed geometry, the turbocharging delivers a substantially constant volume of cooled air Vc when the pressure varies,

and that the volume Vc is substantially proportional to the turbine inlet section Sd offered to the hot gases,

wherein the turbine pressure (P3) is maintained substantially equal to the compressor pressure (P2) by a EGR bypass (3) between the intake manifold (8) and the exhaust manifold (9) dimensioned so as to transfer the flow of exhaust gas to the intake manifold without significant loss of pressure, and the volume of air Vc is less than the volume drawn in by the engine at the speed Nmax in such a way that a flow of hot gases is drawn in again by the engine via the bypass (3) above the speed Na, known as the turbocharging adaptation speed, where the volume drawn in is equal to Vc, and a flow of air is deflected towards the turbine below the speed Na.

2.   Engine as claimed in Claim 1, wherein the EGR bypass (3) has an EGR valve (6) making it possible to increase the turbine pressure above the compressor pressure.

3.   Engine as claimed in Claim 1, wherein the turbocharging unit has an intake valve (7) situated on the compressed air discharge conduit making it possible to increase the compressor pressure above the turbine pressure.

4.   Engine as claimed in Claim 1, wherein the EGR bypass conduit (3) has a gas cooler (4) at an adjustable temperature, preferably adjustable up to a temperature close to that of the fresh air.

5.   Engine as claimed in Claim 4, wherein the adjustment of the temperature is effected by controlling a bypass of the cooler.

6.   Method of supplying an engine as claimed in Claim 4, wherein the EGR temperature is controlled to create the desired excess of air for the combustion in the engine.

7.   Method of supply as claimed in Claim 4, wherein the EGR temperature is controlled so that the mass of the recycled gases remains substantially equal to the mass of the fresh air up to the speed at which this temperature returns to the exhaust temperature, the recycled mass becoming greater than the mass of the fresh air above this speed.

8.   Method of supply as claimed in Claim 5, wherein the gas cooler is totally bypassed when the engine does not deliver propulsive power.

9.   Method of supply as claimed in Claim 8, wherein for cold starting and operating at idling speed the adjustment of the turbine valves (6) and (7) and/or the timing of the engine valves is adjusted so that the excess of combustion air is minimal for the desired level of depollution.

10.   Engine as claimed in Claim 1, wherein the adaptation speed Na is substantially equal to Nmin/2 so that the volume of recycled gases is at least equal to that of the fresh air, and the minimum temperature of the recycled gases is preferably close to the temperature of the fresh air so that the mass of the recycled gases is at least equal to that of the fresh air at the minimum speed used Nmin in order to depollute all the range of use of the engine.

11.   Engine as claimed in Claim 4, wherein the adaptation speed Na is substantially equal to Nmin/2 so that the volume of recycled gases is at least equal to that of the fresh air, and the

minimum temperature of the recycled gases is preferably close to the temperature of the fresh air so that the mass of the recycled gases is at least equal to that of the fresh air at the minimum speed used Nmin in order to depollute all the range of use of the engine.

12. Engine as claimed in Claim 1, wherein the turbocharging unit has a low-pressure LP turbocharger and a high-pressure HP turbocharger of which the compressors work in series with, preferably, a cooling of the air between the compressors and the exhaust outlet section Sd can be adjusted between a minimum Sd min and a maximum Sd max by one or a combination of the following means:

adjustment of the variable section of the gas distributor of the turbines,

opening of a bypass between the inlet and the outlet of the turbines,

passage from a series configuration to a parallel configuration of the turbines,

the turbocharging adaptation speed Na thus becoming adjustable, in a continuous or discontinuous manner, between two values Na min and Na max. In the following, a bypass between the inlet and the outlet of a turbine will be called a waste gate.

13. Engine as claimed in Claim 12, wherein the minimum outlet section Sd min offered to the gases is formed by the two turbines mounted in series at maximum closure if their distributor if variable and all waste gates are closed if they exist.

14. Engine as claimed in Claim 13, which operates on a 4-stroke cycle with a fixed timing of the valves.

15. Engine as claimed in Claim 14, wherein the maximum outlet section Sd max offered to the gases is formed by two turbines with fixed distributors mounted in parallel, and wherein, in order to pass the turbines from the series configuration to the parallel configuration , the following manoeuvres to be carried out successively:

progressive partial opening of the HP waste gate

progressive and simultaneous partial opening of the HP and LP waste gates

simultaneously and rapidly: total opening of the HP waste gate, total closure of the LP waste gate, putting the outlet of the HP turbine into communication with the outlet of the LP turbine.

16. Engine as claimed in Claim 14, wherein the maximum outlet section Sd max offered to the gases is formed by a LP turbine with fixed distributor and a HP turbine with variable distributor mounted in parallel, the HP distributor being fully open, and wherein, in order to pass the turbines from the series configuration to the parallel configuration the following manoeuvres to be carried out successively:

progressive opening of the distributor of the HP turbine

progressive partial opening of the LP waste gate

simultaneously and rapidly: total opening of the LP waste gate and putting the outlet of the HP turbine into communication with the outlet of the LP turbine.

17. Method of supplying an engine as claimed in Claim 2, wherein in order to limit the frequency of changing the configuration the geometry is immobilised for a type of driving which implements a limited power range, for example the series configuration of the turbines for driving in town and the parallel configuration for driving on the open road, and the power thresholds corresponding to each configuration can be crossed for manoeuvres of short duration, such as accelerating, overtaking, bursts of speed, etc., and the thresholds may be crossed as follows:

by closure of the EGR valve if the pressure in the exhaust manifold can be increased,

by opening of one or two waste gates if the exhaust temperature can be increased,

by closure of the intake valve if the maximum cycle pressure is reached or if the compressors are close to their maximum flow rate.

18. Method of supplying an engine as claimed in Claim 3, wherein in order to limit the frequency of changing the configuration the geometry is immobilised for a type of driving which implements a limited power range, for example the series configuration for driving in town and the parallel configuration for driving on the open road, and the power thresholds corresponding to each configuration can be crossed for manoeuvres of short duration, such as accelerating, overtaking, bursts of speed, etc., and the thresholds may be crossed as follows:

by closure of the EGR valve if the pressure in the exhaust manifold can be increased,

by opening of one or two waste gates if the exhaust temperature can be increased,

by closure of the intake valve if the maximum cycle pressure is reached or if the compressors are close to their maximum flow rate.

19.   Method of supplying an engine as claimed in Claim 12, wherein in order to limit the frequency of changing the configuration the geometry is immobilised for a type of driving which implements a limited power range, for example the series configuration for driving in town and the parallel configuration for driving on the open road, and the power thresholds corresponding to each configuration can be crossed for manoeuvres of short duration, such as accelerating, overtaking, bursts of speed, etc., and the thresholds may be crossed as follows:

by closure of the EGR valve if the pressure in the exhaust manifold can be increased,

by opening of one or two waste gates if the exhaust temperature can be increased,

by closure of the intake valve if the maximum cycle pressure is reached or if the compressors are close to their maximum flow rate.

20.   Engine as claimed in Claim 15, wherein the LP waste gate has a second seat in order simultaneously to effect the closure of the LP turbine inlet/outlet bypass and putting the HP turbine outlet into communication with the LP turbine outlet.

21.   Engine as claimed in Claim 15, wherein the two waste gates are concentric and have stops in such a way that their simultaneous movements are actuated by one of them and communicated to the other by the said stops.

22.   Engine as claimed in Claim 14, wherein the maximum outlet section Sd max is formed by two turbines with fully open variable distributors mounted in series, and the distributors are opened simultaneously in order to maintain the intake pressure at its maximum desired value on the full load curve.

23.   Engine as claimed in Claim 13, wherein the timing of the valves can be controlled so as to displace the closure of the cylinder between the vicinity of the BDC and the mid-stroke of the piston, the maximum outlet section Sd is formed by the HP turbine in series

configuration with the distributor fully open if it is variable, the HP waste gate fully open in the contrary case. The turbines are dimensioned so as to permit the compressors to reach their maximum pressure ratios simultaneously.

24.   Method of supplying an engine as claimed in Claim 23, wherein the full load curve as a function of the speed is as follows:

from Nmin to 2 Nmin the intake closure Fa passes from the BDC (bottom dead centre) to approximately 90 degrees of the crankshaft after the BDC in such a way as to maintain the cycle pressure below its desired value,

the distributor or the HP waste gate is closed;

from 2 Nmin to approximately 3 Nmin the HP distributor or the HP waste gate is open and possibly the LP waste gate in order to main the intake pressure at its maximum desired value,

FA is maintained at 90 degrees of the crankshaft after the BDC,

from 3 Nmin to Nmax the global flow rate of fuel is kept constant in order to maintain the intake pressure at its limiting value,

at partial load the timing of FA will be controlled according to a map memorised by the engine control computer.

25.   Engine as claimed in Claim 13, which operates on the 2-stroke cycle, and wherein the intake ports are closed by valves,

the exhaust ports are closed by valves and communicate with one single exhaust manifold,

the external recycling phase precedes the scavenging,

the timing of the valves can be controlled so as to displace the closure of the cylinder between the vicinity of the BDC and the mid-stroke of the piston,

the maximum outlet section Sd is formed by the HP turbine in series configuration with the distributor fully open if it is variable, the HP waste gate fully open in the contrary case,

the turbines are dimensioned so as to permit the compressors to reach their maximum pressure ratios simultaneously,

the EGR valve is replaced by a check valve or a closable aerodynamic diode.

26.   Method of supplying an engine as claimed in Claim 25, wherein the full load curve as a function of the speed is as follows:

from Nmin to 2 Nmin the closure of the cylinder passes from the BDC to approximately 90 degrees of the crankshaft after the BDC in such a way as to maintain the cycle pressure at its desired value,

the distributor or the HP waste gate is closed,

from 2 Nmin to approximately 3 Nmin the HP distributor or the HP waste gate is open and possibly the LP waste gate in order to main the intake pressure at its maximum desired value,

FA is maintained at 90 degrees of the crankshaft after the BDC,

from 3 Nmin to Nmax the global flow rate of fuel is kept constant in order to maintain the intake pressure at its limiting value,

where, in order to maximise the cooled external EGR, the depolluted partial loads can be effected as follows:

the cylinder remains closed in the vicinity of the BDC and the turbines remain in closed configuration up to the P2 limit for this timing,

the turbines are then opened in order to maintain P2 at its limiting value,

the aerodynamic diode when the external recycling flow stops.

27.   Engine as claimed in Claim 13, which operates on the 2-stroke cycle, it has two exhaust ports per cylinder, closed by valves, which communicate respectively with an exhaust manifold connected to the turbine and an exhaust manifold connected to the EGR conduit and/or to the turbine via a controlled distributor valve, where the timing of the valve assigned to the EGR can be controlled so as to displace the closure of the cylinder between the vicinity of the BDC and the mid-stroke of the piston,

the external recycling phase precedes the scavenging when the cylinder closes in the vicinity of the BDC and follows it when the cylinder closes at the mid-stroke of the piston.

the maximum outlet section Sd is formed by the HP turbine in series configuration with the distributor fully open if it is variable, the HP waste gate fully open in the contrary case.

the turbines are dimensioned so as to permit the compressors to reach their maximum pressure ratios simultaneously.

the EGR valve is replaced by a check valve or a closable aerodynamic diode.

28.   Method of supplying an engine as claimed in Claim 27, wherein the pressure P2 is lower than the limit allowed for this timing,

the distributor valve is in the recycling position,

the cylinder is closed in the vicinity of the BDC,

the distributor or the HP waste gate are closed,

the pressure reaches the limiting value allowed for this timing, the closure of the cylinder. is displaced to the mid-stroke of the piston in order substantially to double the allowed P2 limit,

the distributor valve remains in the recycling position,

the distributor or the HP waste gate remain closed,

the pressure P2 reaches the new limit allowed for this new timing, the distributor :valve blocks the recycling,

the distributor or the HP waste gate opens in order to keep the P2 at its new allowed limit,

the transition can be made progressively in the two directions or rapidly with a hysteresis.

29.   Method as claimed in Claim 6, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

30.   Method as claimed in Claim 7, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

31.   Method as claimed in Claim 8, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable

geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

32.   Method as claimed in Claim 9, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

33.   Method as claimed in Claim 17, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

34.   Method as claimed in Claim 18, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

35.   Method as claimed in Claim 19, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

36.   Method as claimed in Claim 24, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

37.   Method as claimed in Claim 26, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

38. Method as claimed in Claim 28, wherein at full load the variable geometry is controlled so as to maintain a parameter at its limiting desired value; at partial load the variable geometry is controlled so as to optimise the depollution and/or the performance according to a map memorised in the engine control computer.

39. Engine as claimed in Claim 1, including a flat cylinder head bearing valves of which the faces on the chamber side are coplanar with the cylinder head and substantially tangent to the cylinder, wherein the intake pipe or pipes terminate(s) by an oblong nozzle defined by an upper half-cylinder resting on the upper edge of the conical seat and tangent to this latter along its generating line situated in a plane substantially perpendicular to the plane passing through the axis of the seat and through the axis of the cylinder and through a lower cylinder covering half of the valve head opposite the said generating line, the nozzles are also oriented so as to create a tangential speed in the same direction, and the angles of the seats are chosen so as to optimise the stratification of the combustive charge.

40. Engine as claimed in Claim 1, including a flat cylinder head bearing valves of which the faces on the chamber side are coplanar with the cylinder head and substantially tangent to the cylinder, wherein the conical sealing bearing surface of the intake valves is extended towards the piston by a cylindrical part of a height slightly greater than the lift of the said valves, the conical seats of the said valves are disposed at the bottom of cylindrical recesses provided in the cylinder head in order to receive the said cylindrical parts of the said valves in such a way that the flat lower faces of the valves are in the plane of the cylinder head when they rest on their seats, the clearance between the recesses and the valves being minimal, and recesses are provided in the cylinder head which do not go beyond the following boundaries:

> two cylindrical portions concentric with the bore and tangent externally and internally to the cylindrical recess of each valve,
>
> a conical surface extending the half-seat of the valve delimited by a plane passing through the axis thereof and the axis of the cylinder,
>
> the recesses will also be oriented so as to create a tangential velocity in the same direction,

the angle of the seats is chosen so as to optimise the stratification of the combustive charge.

41. Engine as Claimed in Claim 39, wherein it includes two diametrically opposed intake valves.

42. Engine as Claimed in Claim 40, wherein it includes two diametrically opposed intake valves.

43. Engine as claimed in Claim 1, wherein a fraction of the recycled gases is retained in the cylinder at the closure of the latter, the fresh gases are introduced by directive intake conduits with the aim of organising a stratification of the temperatures and the concentrations in the chamber at the combustion top dead centre, and the fuel is vaporised in the fresh gases.

44. Engine as claimed in Claim 43, wherein the fuel is introduced into the pure air between the compressor and the external EGR mixer.

45. Engine as claimed in Claim 43, wherein the fuel is introduced into the mixture between the pure air and the external EGR.

46. Engine as claimed in Claim 43, wherein the ignition point is controlled by the timing of the valves at the closure of the cylinder.

47. Engine as claimed in Claim 43, wherein the ignition point is controlled by the temperature of the external EGR.

48. Engine as claimed in Claim 43, wherein the first ignition is controlled electrically or is triggered spontaneously by the injection of the fuel at high pressure at the top dead centre.

49. Engine as claimed in Claim 43, wherein the working chamber of the gases has a geometry revolving around the axis of the cylinder. The stratification has a geometry revolving around the axis of the cylinder and created by the orientation of the intake ports,

the temperature of the combustive charge increases between the periphery and the axis so that the self-ignition is propagated from the centre towards the periphery.

50. Engine as claimed in Claim 49, wherein the meridian profile of the combustion chamber is chosen so as to optimise the rate of release of energy by the progressiveness of the isothermal surfaces of the reactive load.